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THE DESIGN AND ANALYSIS OF PISTON - STEADY STATE THERMAL ANALYSIS USING "ANSYS"

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ABSTRACT

In this study thermal analysis on piston made of aluminium alloy are absorbed Internal combustion engines have been a relatively inexpensive and reliable source of power for applications ranging from domestic use to large scale industrial and transportation applications for most of the twentieth century. DI Diesel engines, having the evident benefit of a higher thermal efficiency than all other engines, have served for both light- duty and heavy-duty vehicles. But when the piston moves towards Top Dead Centre (TDC), the bowl geometry has a significant effect on air flow thereby resulting in better atomization, better mixing and better combustion. As the main heating part in the engine, piston works for a long time in high temperature and high load environment. The piston has the characteristics of large heating area and poor heat dissipation, so the thermal load is the most serious problem. In this work, the main emphasis is placed on the study of thermal behaviour of functionally graded materials obtained by means of using a commercial code ANSYS on aluminium alloy piston surfaces. Using CREO software the structural model of a piston will be developed. Furthermore, the steady state thermal analysis is done using Computer Aided Simulation software ANSYS.

KEYWORDS: Diesel engines, ANSYS & CREO

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Original Article

INTRODUCTION

The increasing trends and demands in the automotive world, there are always tug and tie between the designer and customer. To cope with existing competition in the modern times there is always need for great improvement in compatibility of the engine models. In this chapter the brief introduction about the Internal Combustion engine (IC engine) is presented. The various components, type and recent advancements in IC engine are also presented in this chapter.

The distinctive feature of IC engine is that combustion and conversion of heat energy into mechanical work occur inside the cylinder. These engines are noted for their efficiency and low operating cost. In this project we have used kirloskar engine's piston for design and analysis purpose.

GENERAL INFORMATION

There are two distinct types of pistons:

- Trunk type piston
- Crosshead type piston

Trunk Type piston

The CROWN, or head, of a piston acts as the moving surface that changes the volume of the content of the cylinder (compression), removes gases from the cylinder (exhaust), and transmits the energy of combustion (power). Generally, the crown end of a piston is slightly smaller in diameter than the skirt end. The resulting slight taper allows for expansion of the metal at the combustion end. Even though slight, the taper is sufficient so that, at normal operating temperatures, the diameter of the piston is the same throughout.

Crosshead Pistons

A type of crosshead piston is currently being used in some engines. The crosshead piston is a two-piece unit with a crown that can withstand the high heat and pressure of a turbocharged engine and a skirt specifically designed to absorb side thrust. The crown and skirt are held together by the piston pin. The downward load on the crown pushes directly on the pin through a large slipper bearing (bushing). The separate skirt has less thermal distortion than the crown piece and is free of downward thrust loads. It specifically guides the piston in the cylinder, takes up side thrust, and carries the oil scraper rings.used in engineering structures and components where light weight or corrosion resistance is required.

Thermal Steady-State Conduction

Steady state conduction is the form of conduction that happens when the temperature difference(s) driving the conduction are constant, so that (after an equilibration time), the spatial distribution of temperatures (temperature field) in the conducting object does not change any further. Thus, all partial derivatives of temperature *with respect to space* may either be zero or have nonzero values, but all derivatives of temperature at any point *with respect to time* are uniformly zero. In steady state conduction, the amount of heat entering any region of an object is equal to the amount of heat coming out (if this were not so, the temperature would be rising or falling, as thermal energy was tapped or trapped in a region

Softwares Used: Parts of the Piston

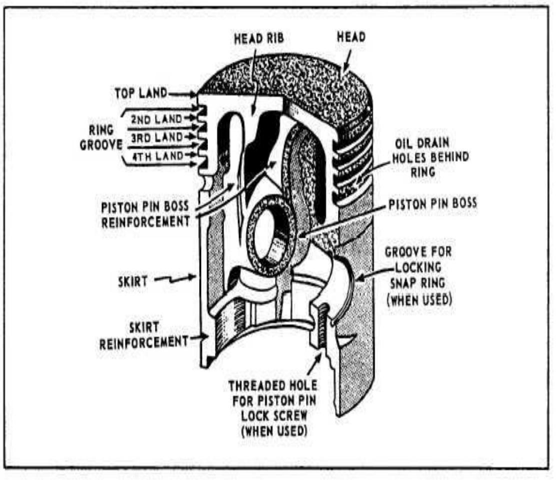

Figure 1

- DESIGN: CREO
- ANALYSIS: ANSYS WORKBENCH

Piston Material: **Aluminium Alloy**

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0–13%) contribute to give good casting characteristics. Aluminium alloys are widely

INPUT DATA FOR ANALYSIS IN SOFTWARE

Table 1

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Length X	87.5 mm
Length Y	132. mm
Length Z	87.504 mm
Volume	2.646e+005 mm^3
Mass	0.73295 kg
Nodes	193904
Elements	129519
Scale Factor Value	1

(at no load condition)

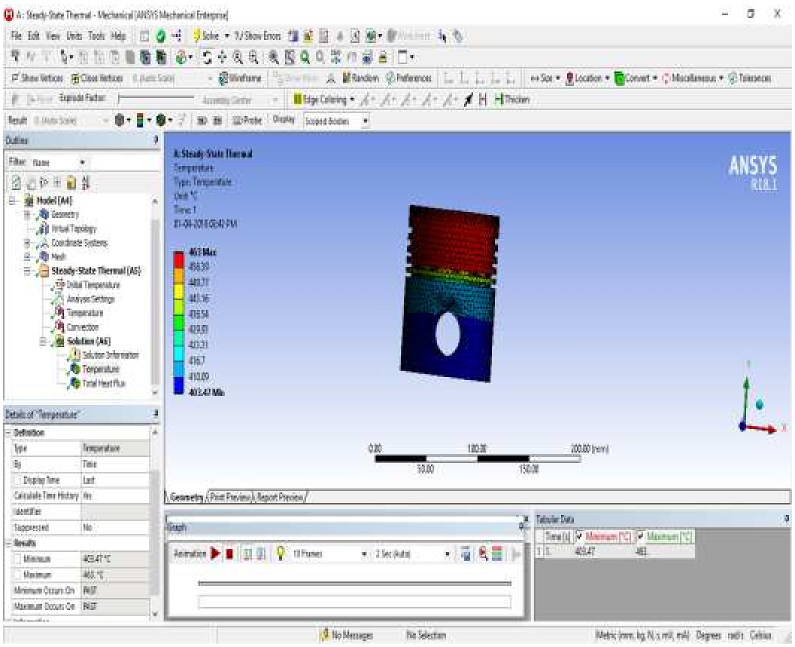

Figure 2: Ansys Output of Original Piston.

MODELS TO BE CONSIDERED FOR THIS ANALYSIS

- Model 1
- Model 2
- Model 3

Modelling

Model 1

Figure 3: Piston with Varying Bowl Diameter

Model 2

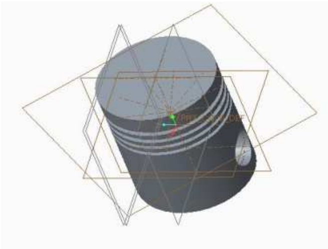

Figure 4: Piston with Flat Head.

Model 3

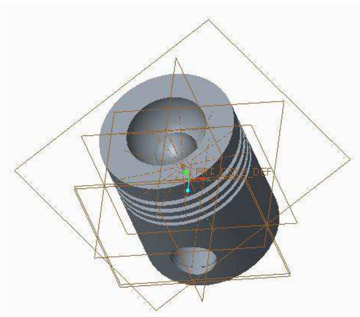

Figure 5: Piston with Hemisphere Inside Bowl

After modelling all 3 models were analyzed in ANSYS for thermal steady state temperatures and post processor output are given from Figures 5 to 7.

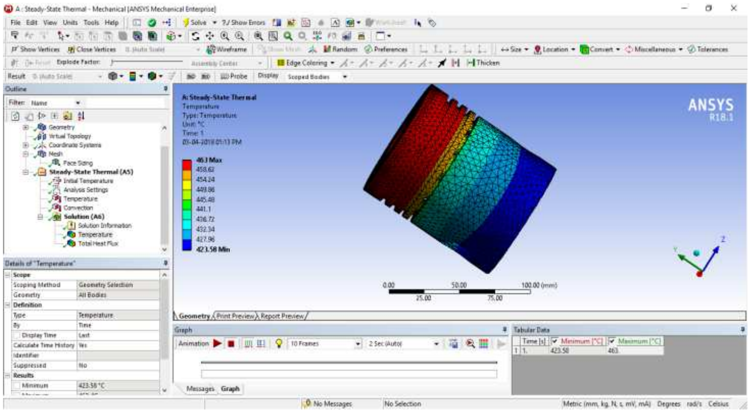

Figure 6: Ansys Solution for Model 1.

Steady-State Thermal- Convection

Table 2

Temperature [°C]	Convection Coefficient [W/mm²·°C]
21	5.e-006

Steady-State Thermal-Solution-Temperature

Table 3

Time [s]	Minimum [°C]	Maximum [°C]
1.	423.58	463.

Steady-State Thermal - Solution -Total Heat Flux

Table 4

Time [s]	Minimum [W/mm²]	Maximum [W/mm²]
1.	1.7065e-004	1.6978

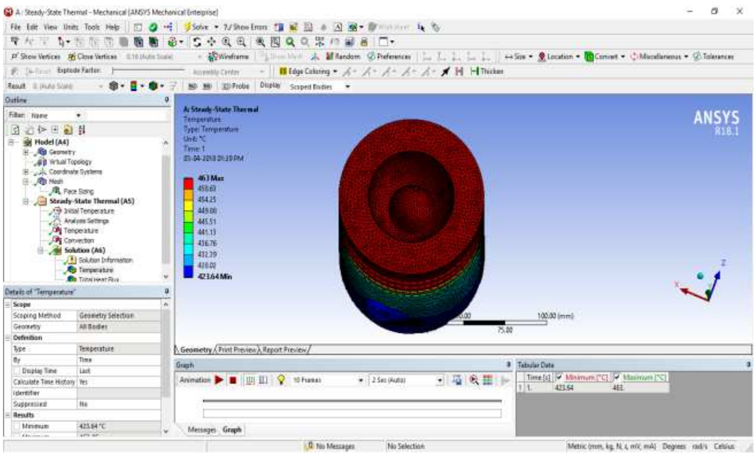

Figure 7: Ansys Solution for Model 2

Steady-State Thermal- Convection

Table 5

Temperature [°C]	Convection Coefficient [W/mm²·°C]
21	5.e-006

Steady-State Thermal - Solution – Temperature

Table 6

Time [s]	Minimum [°C]	Maximum [°C]
1.	415.83	463.

Steady-State Thermal – Solution - Total Heat Flux

Table 7

Time [s]	Minimum [W/mm²]	Maximum [W/mm²]
1.	1.5451e-005	1.718

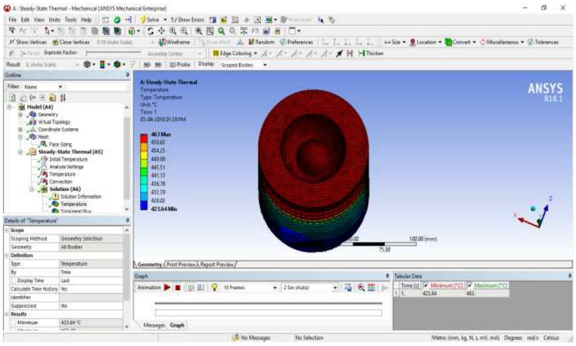

Figure 8: Ansys Solution for Model 3

Steady-State Thermal- Convection

Table 8

Temperature [°C]	Convection Coefficient [W/mm²·°C]
21	5.e-006

Steady-State Thermal - Solution – Temperature

Table 9

Time [s]	Minimum [°C]	Maximum [°C]
1.	423.64	463.

Steady-State Thermal - Solution - Total Heat Flux

Table 10

Time [s]	Minimum [W/mm²]	Maximum [W/mm²]
1.	3.2348e-004	2.2762

CONCLUSIONS

The thermal stress field only caused by the uneven temperature distribution was obtained in this study. To simulate the stress field, the steady-state temperature field was calculated. A rise in piston temperature had a substantial in reducing the exhaust emissions.

By using CAD and FEA software piston has been modified and analysed. The obtained results show that piston that belonging to model 3 has better temperature capacitance than others. While comparing the standard piston, the modified piston has good results.

Table 11

TIME(sec)	1	1	1	1
TEMP(C)	403 °C	423.58°C	415.83°C	423.64°C

REFERENCES

1. *Yaohui Lu, Xing Zhang, Penglin Xiang, Dawei Dong "Analysis of Thermal Temperature Fields and Thermal Stress under Steady Temperature field of Diesel Engine Piston" Applied Thermal Engineering (2016)*
2. *Shahanwaz Adam Havale1, Prof. Santosh Wankhade2 " DESIGN, THERMAL ANALYSIS AND OPTIMIZATION OF A PISTON USING ANSYS" International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 12 | Dec-2017*
3. *G.Anusha1, Ramlakshmi2, K Mohan Krishna3, P.Prem Kumar 4 " Modeling and Analysis of Piston Design through Pro/E & ANSYS" International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 06 | Sep-2015*
4. *Beg.R.A, P.K.Bose, Jadavpur University and B.B.Ghoshi, T.Kr. Banerjee and A.Kr.Ghosh, IIT Kharagpur, "Experimental Investigation on Some Performance Parameters of a Diesel Engine Using Ceramic Coating On The Top Of the Piston". SAE - 970207.*
5. *J Paul Rufus Babu1*, B Madhu Babu1, T Dada Khalandar1 and P S Bharadwaj1 "EXPERIMENTAL INVESTIGATION OF RHOMBUS SHAPED GROOVES ON PISTON CROWN OF A SINGLE CYLINDER 4-STROKE DI DIESEL ENGINE" Int. J. Mech. Eng. & Rob. Res. 2015*
6. *Rao, N. D. P., Krishna, M. M., Prasad, B. A., & MURTHY, P. The effect of thermal barrier coating on exhaust emissions and combustion characteristics of diesel engine with rice brawn oil based biodiesel. International Journal of Research in Engineering and Technology, ISSN (E), 2321-8843.*
7. *Rasul M G and Glasgow R (2005), "Performance Improvement of an Internal Combustion Engine", Proceedings of the International Conference on Mechanical Engineering (ICME2005), ICME05-42, December 28-30, Dhaka, Bangladesh*
8. *Mallavarapu Nageswari1, Vijaya Kumar2 " THERMAL & STATIC ANALYSIS ON IC ENGINE PISTON USING FEA" International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 12 | Dec-2015*
9. *MuhammetCerit*, Mehmet Coban "Temperature and thermal stress analyses of a ceramic-coated aluminum alloy piston used in a diesel engine" International Journal of Thermal Sciences 77 (2014) 11-18*
10. *Vaishali R. Nimbarte, Prof. S.D. Khamankar "Stress Analysis Of Piston Using Pressure Load And Thermal Load" IPASJ International Journal of Mechanical Engineering (IIJME) Volume 3, Issue 8, August 2015*
11. *S.Jaichandar and P.Tamilporai, Anna University, Chennai,"Low Heat Rejection Engines -An Overview".SAE 2003-01-0405.*
12. *Mahrous, A. (2013). Thermal performance of PCM based heat sinks. Int J Mech Eng, 2(4).*
13. *Jesse G. Muchai, Ajit D. Kelkar, David E. Klett, and JagannathanSankar, North Carolina A & T State University," Thermal-Mechanical Effects of Ceramic Thermal Barrier Coatings on Diesel Engine Piston". Material Research Society.*
14. *Widjaja S., Limarga A., Ticj H. Y., Modelling of residual stresses in a plasma sprayed zirconia / alumina functionally – thermal barrier coating, Thin Solids Films434(2003), Pages 216-227*